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DISTURBANCE CAUSED BY AIRCRAFT NOISE

R. Josse

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16. Abstract This article is concerned with noise pollution caused by the presence of airfields adjacent to residential areas. Its aim is to evaluate noise effects on sleeping activities of people living near airports, to evaluate the degree of noise tolerance of these residents, to determine aeronautical noise characteristics considered as annoying, and to define the extent to which the annoyance varies with sound levels.					
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DISTURBANCE CAUSED BY AIRCRAFT NOISE

R. Josse

We know how important air transport has become since the end of the last World War.

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The enormous development of this means of transport has been manifested by an expansion of existing aerodromes, the creation of new aerodromes, the appearance of extremely powerful and noisy aircrafts, a considerable increase in air traffic.

This explosive development has not taken place without inconveniencing residents living near airfields. These disturbances are manifested by individual complaints and group actions which are becoming more and more numerous.

It is mainly the psychophysiological effects of noise, which cause people to complain and groups to act.

The situation of residents of homes near existing aerodromes, and they are numerous since airports are often located in high density population regions, will only become worse because of the expansion of air traffic and the use of more and more powerful airplanes. In spite of an experiment in London (1), home soundproofing seems difficult to achieve.

If little can be done for existing residents near airports, government should not authorize the construction of new homes at locations where noise is an annoyance or is likely to become annoying in the future. In order to make decisions, government officials must have guide-lines which take into account the opinions of doctors, psychologists, sociologists, economists, etc.

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1. See "Aircraft noise", Report of an international conference on the reduction of noise and disturbance caused by civil aircraft, London Her Majesty's Stationery Office, 1967.

*Numbers in the margin indicate pagination in the foreign text.

This investigation, of which we will give the main conclusions, is the result of a collaboration between doctors, psychologists and engineers. It may serve as a source of information for establishing such guidelines.

This study was financed by the Délégation Générale à la Recherche Scientifique et Technique and was executed by the Centre Scientifique et Technique du Bâtiment in collaboration with the Association d'Anthropologie Appliquée. The main objectives of this study have been:

- to evaluate noise effects on sleeping activities of people living near airports,
- to evaluate the degree of noise tolerance of these residents,
- to determine aeronautical noise characteristics considered as annoying,
- to define the extent to which the annoyance varies with sound levels.

American studies and one British study have already been conducted on the same subject:

- in 1952, by Mr. Paul BORSKY from the "National Opinion Research Center", of the University of Chicago,
- in 1955-1957, by Mr. Paul BORSKY for the "United States Air Force",
- in 1961, by Mr. A.C. MCKENNEL upon the instigation of the "Wilson Committee on the Problem of Noise".

Our investigation was conducted in a similar manner as the British study, but covered four aerodromes instead of one:

- Orly,
- Le Bourget,
- Lyon-Bron,
- Marseille-Marignane

Before beginning the survey on people living near airports, we conducted a measuring campaign in order to determine the inhabited locations for which noise conditions vary in intensity and in the number of airplanes heard. These locations were selected under the main take-off trajectories of different airports.

The measurements were performed from May 1965 to April 1966 on 29 points for the Paris region and on 14 points for the provinces. Only 20 points were selected for the survey (13 in the Paris region and 7 in the provinces).

The measurements were made with recorders which operated continuously for several days for for several weeks. The microphone was placed above the roof of buildings, making it possible to determine the average peak noise level L (measured in dB (A) and expressed in PN dB after a correction) and the number N of airplanes heard daily. Some corrections were made to take into account the fact that the traffic could be different during the measuring period from the average yearly traffic.

$$L_{dn} = L_A + 10 \log N - 39.4$$

$$L_{dn} = (L_A + 10 \log N - 39.4) - 13 - 5.4 = R - 17.4$$

Knowledge of these two fundamental parameters has made it possible to easily calculate:

-The isopsophic index R defined by the Noise Commission of the Ministry of Social Affairs.

$$R = \bar{L} + 10 \log N - 34$$

\bar{L} PN dB

L is the average peak level defined as the quadratic average level of maximum acoustical pressures produced by different airplanes heard on the point under consideration:

$$\bar{L} = 10 \log_{10} \left[\frac{1}{N} \sum_{n=1}^{n=N} 10^{L_n/10} \right]$$

L_n stands for the maximum acoustical pressure level on an external point free from any obstacle produced by the passage of airplane n° ;

-The Noise Number Index used in Great Britain.

$$NNI = \bar{L} + 15 \log N - 80$$

These indices have been calculated by considering either all noise points (24 hr), or only noise points produced during the night (9p.m. - 7 a.m.). The corresponding indices are called "day" and "night" indices.

The average peak levels recorded have varied, depending on the locations, from 93 to 111 PN dB and on the number of airplanes heard, from 63 to 100.

The reaction of the inhabitants to noise, was evaluated by a survey conducted on 2,000 individuals by the Association d'Anthropologie Appliquée:

800 individuals near Orly airport,
500 individuals near Bourget airport,
400 individuals near Lyon airport,
300 individuals near Marseilles airport.

The survey took place from November 1965 to April 1966.

The questionnaire contained thirty questions, some of which were combined to form two attitude scales developed from the Guttman hierarchical analysis method.

-an annoyance scale based on the five following questions, listed in hierarchical order.

Q. 17. Does airplane noise annoy you?

Q. 18C. Does airplane noise bother you when you watch t.v. or listen to the radio?

Q. 18F. Does it disturb conversations?

Q. 18G. Does it bother or annoy you at other moments or for other reasons?

Since one point is assigned to each positive response to each of these questions, the annoyance range may vary from 0. to 5;

-A satisfaction scale made up in the same way from eight questions:

The processing of all data was performed on a computer and the main conclusions of the study are the following:

1. The investigation confirmed that the annoyance range is an increasing function of the noise index as calculated either by the method recommended by the Noise Research Commission of the Ministry of Social Affairs (index R), or by the method resulting from the English study (NNI index).

Even though they differ by the way of accounting for the Noise Number Index ($10 \log N$ or $15 \log N$), these two indices have proven to be equal in consideration of the variety of individual reactions for a same noise zone. /48

Knowing the value of such an index makes it possible to predict quite accurately the average annoyance tolerance experienced by a group of individuals living in a given location.

On the other hand, individual reactions are so diverse, that it is impossible to predict them: in quiet areas, some people surveyed were annoyed by airplanes. In the highest noise level areas, there is always a portion of the population which does not feel annoyed.

It has been brought to light that the average annoyance range increases linearly with R, for the range studied ($63 < R < 100$) except in the vicinity of $R = 86$, value at which it undergoes an upward fluctuation from 2 to 2.8.

If the annoyance range presents the advantage of accounting for answers to several questions, it has the drawback of not "speaking". To see what it corresponds to, we thought it would be useful to illustrate (fig. 1) the different annoyance scale levels and the general impression of annoyance expressed in the answers to question 9.

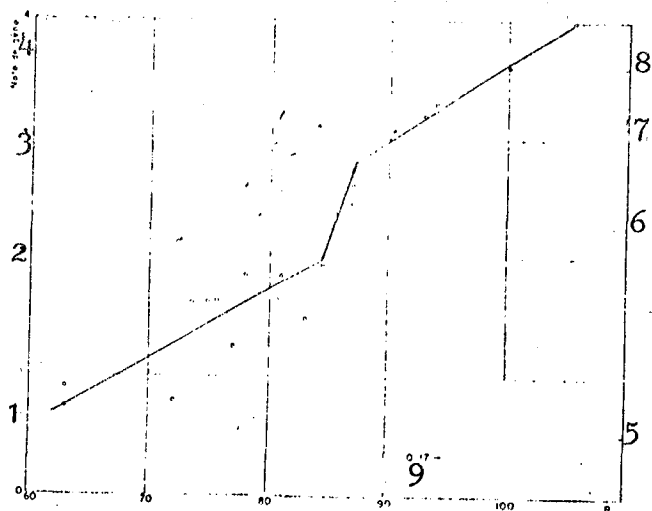
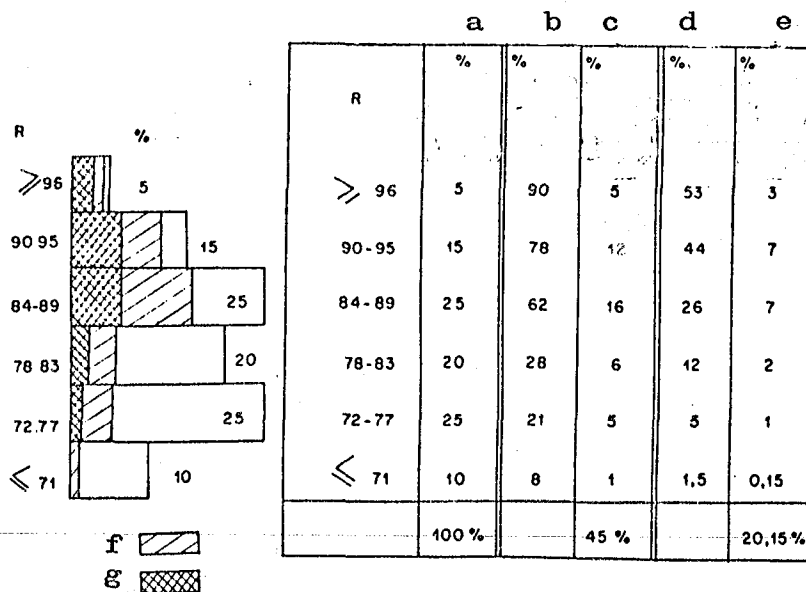


Fig. 1- Annoyance variation with noise index

Key: 1-annoyance; 2-disturbs radio-t.v. listening; 3-disturbs conversations; 4-noise awakens; 5-not at all; 6-moderately; 7-considerably; 8-extremely; 9-Does aircraft noise annoy you?

The upward fluctuation in the annoyance range observed in the vicinity of $R=86$ corresponds to the fact that the answer "yes" to question 18 F "does airplane noise annoy conversations?" occurs when the index exceeds a relatively precise value. This may be seen on the table of figure 2. This is not surprising, for contrary to the

feeling of annoyance which involves psychological effects, the drowning of a conversation depends only on noise intensity relative to that of the voice; this latter intensity is well-defined.



Key: a-individuals surveyed by sound level versus total sampling; b-ranges greater than or equal to 3 per noise class; c-ranges greater than or equal to 3 of the noise class versus total sampling; d-ranges 4 by noise class; e-ranges 4 of the noise class versus total sampling; f-range equal to or above 3; g-range equal to 4 or 5.

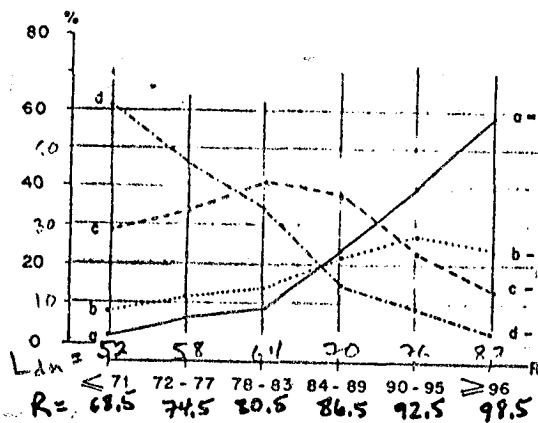
Graph points 1 located in the zone of discontinuity (vicinity of $R = 86$) correspond to peak levels varying between 101 and 107 PN dB,

Fig. 2-Sampling distribution and annoyance ranges 3 and 4 as a function of sound classes.

i.e. 92 to 98 dB (A), with a number of overhead flights ranging between 20 and 80.

The levels at which "yes" is answered to the annoyance scale questions other than 18 F are more spread out. For this reason, the annoyance range increase is linear with the noise index outside the zone of discontinuity.

Figures 3, 4, 5 and 6 give the percentages of answers to isolated questions:



Key: a-extremely; b-moderately; c-a little; d-not at all.

Fig.3-Does airplane noise bother you?

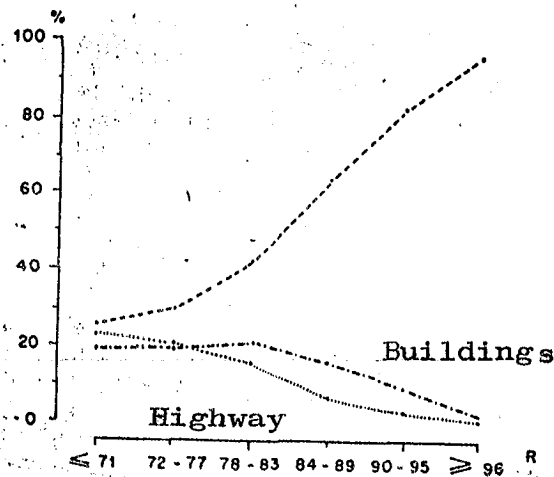
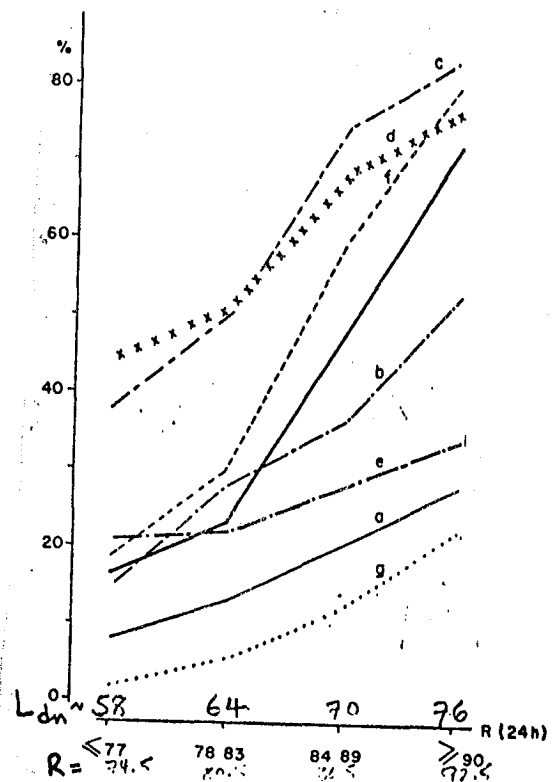


Fig. 4-Which noise annoys you the most?



Key: c-disturbs radio t.v.; f-masks conversations; d-vibrates the house; Q 17-general impression (highly + moderately annoyed); b-awakens; e-startles; a-prevents sleeping; g-other

Fig. 6 - Percentages of annoyed individuals surveyed (by sound class) (answers: sometimes + quite often).

% answers = airplanes

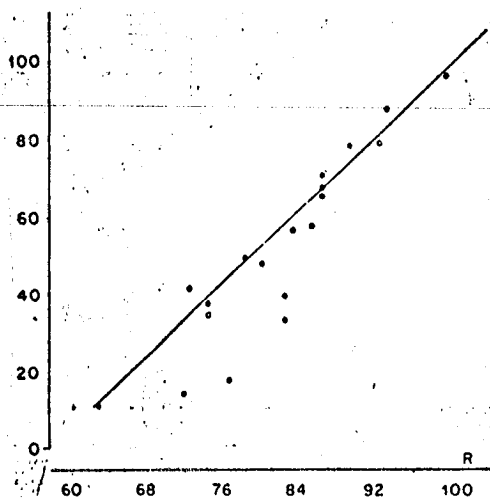
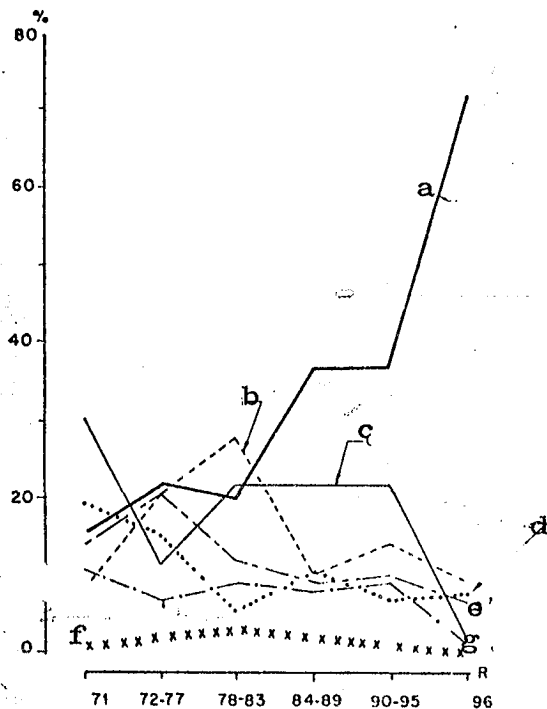
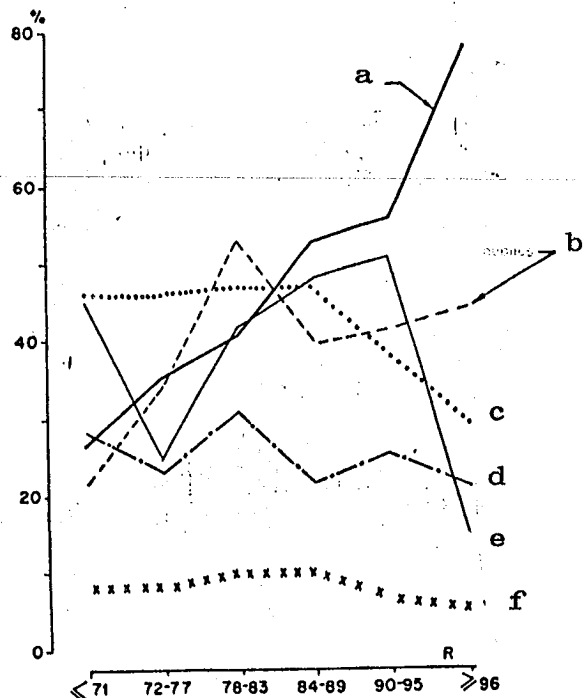


Fig. 5- Which noise annoys you the most? By locations.



Key: a-noise; b-public transport; c-buisenesses; d-amusments; e-no answer; f-commuting distance; g-neighbors

Fig. 8-What would you change?

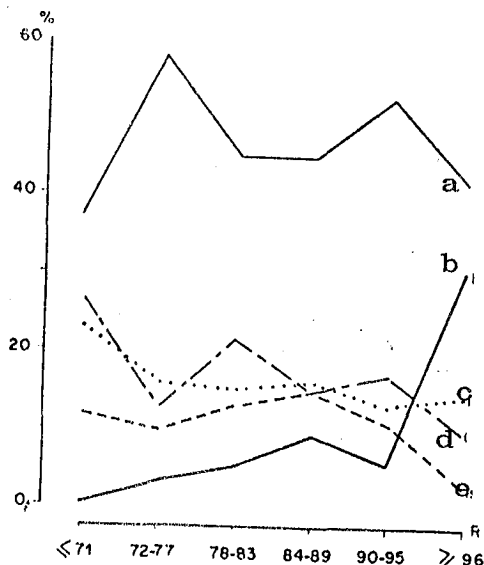


Key: a-noise; b-public transports; c-amusments; d-commuting distance; e-business; f-neighbors

Fig. 7-Causes of dissatisfaction

2. Noise class 84-89 gives the disturbance limit for conversations, which appears to play an important role.

If we refer to figure 7, we note that noise is a cause of dissatisfaction which emerges from other causes of dissatisfaction (businesses, transports...) when the index reaches class 84-89. Likewise, to the question, "what would you change?" (fig. 8)



Key: a-better housing; b-noise; c-misc.; d-unpleasant neighborhood; e-isolation, distance.

Fig. 9--Why do you want to move?

committee, which pursued the English survey, and which specified that the maximum allowable noise index is located between 50 and 60 NNI.

(An NNI index of 50 corresponds, for 80 overhead flights, to a peak level of 100 PNdB, or an R index of about 85).

It may be stated, by observing figure 9, that the housing crises is such that noise is not, except at very high levels, a main cause of moving.

3. By the nature of the questions, the annoyance range accounts for both day and night annoyance. Moreover, for noise class $R = 84/89$, which corresponds to annoyance ranges from 2 to 3, night annoyance occurs only occasionally, since night annoyance (awakening) corresponds to ranges 4 and 5. In fact, we have stated that the variety in individual sensitivity to noise at night is considerable, regardless of the noise index used (index R, number of airplanes passing overhead, noise level in PNdB) to characterize the different zones. Accordingly,

the answer is "noise" more than any other item when the index reaches 84-89. For this class, the inhabitants have answered "a little or moderately annoyed".

The convergence of these observations makes it possible for us to consider that at class 84/89, which corresponds to an annoyance range above 2, airplane noise becomes obviously annoying for the inhabitants.

As a result, it appears that an uninsulated home should not be located anywhere where R exceeds 84. This conclusion coincides with the conclusions of the Wilson

for class R = 84/89, 26% of the individuals surveyed said they were awakened at night by airplanes (fig. 2). Accordingly, for this same relatively low noise class, there is a combination of day and night effects to evaluate the annoyance level.

This global evaluation of night and day effects does not allow for an evaluation of how it would vary if noise conditions at night increased.

4. We have attempted to examine the relationship between night annoyance and noise characteristics (9 p.m. to 7 a.m.).

We have found a small correlation between the noise index (of night) and the percentage of individuals awakened or having difficulty falling to sleep (fig. 10). This does not make it possible to affirm

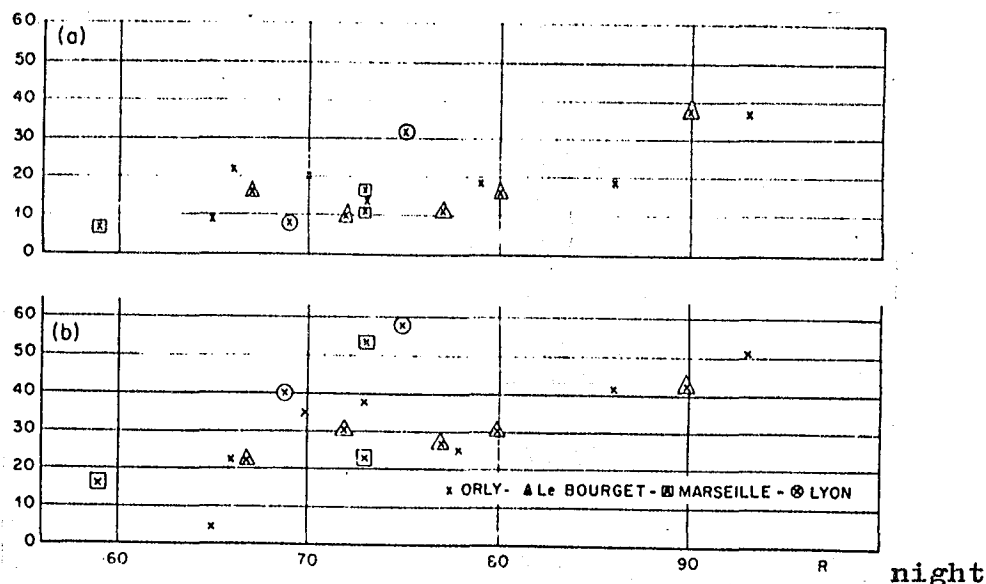
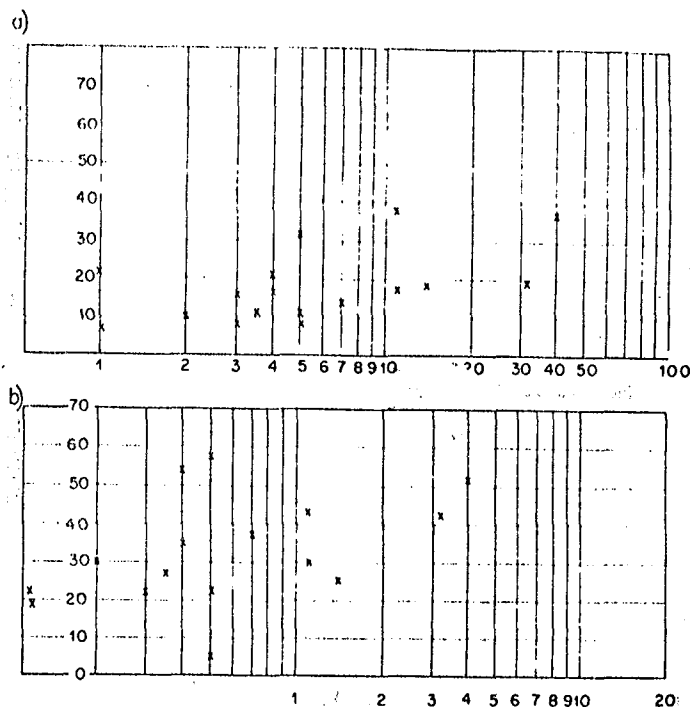


Fig. 10 - Percentage of individuals who could not fall to sleep (A) or who were awakened by airplane noise (b).

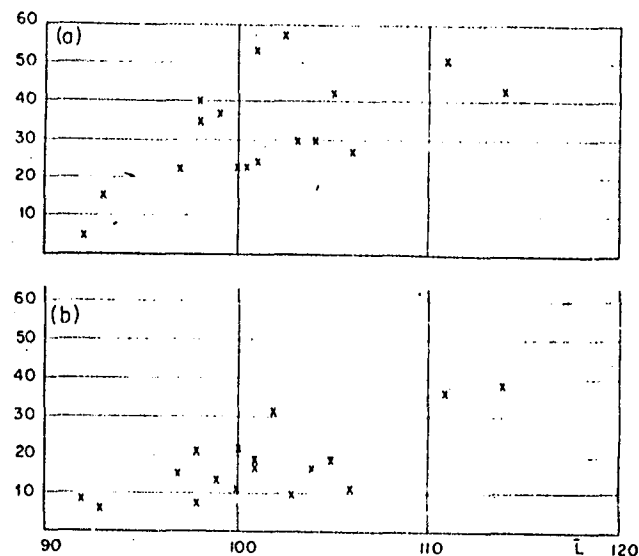
that the noise index concept (R) is not valid in this case. The poor correlation may be partially due to the fact that the measurements of noise are not large because of the considerable fluctuation in night traffic, depending on the days of the year, the use, the location of

of index R, the average peak level \bar{L} or the number N of airplanes passing over, is not more satisfactory (fig. 11 and 12). It is rather surprising to note (fig. 13) that it is index R calculated over a 24 hour period which proves to be the most related to night disturbance.



Key: a-% could not fall asleep; b-% awakened; c-number of noise points (night); d-number of noise points (day)

Fig. 11-Percentage of individuals who could not fall asleep (a) or who were awakened by airplane noise (b).



Key: a-% awakened; b-% who could not fall asleep.

Fig. 12-Percentage of individuals awakened by airplane noise (a) or who could not fall asleep (b).

In conclusion, the present study has brought to light additional information on the overall annoyance felt on the average by individuals under the effects of airplane noises and on its disturbance to some of their activities. On the other hand, personal factors cause some people to react quite differently to noise compared to the group average. Future research should examine these factors and the problems of night disturbance.

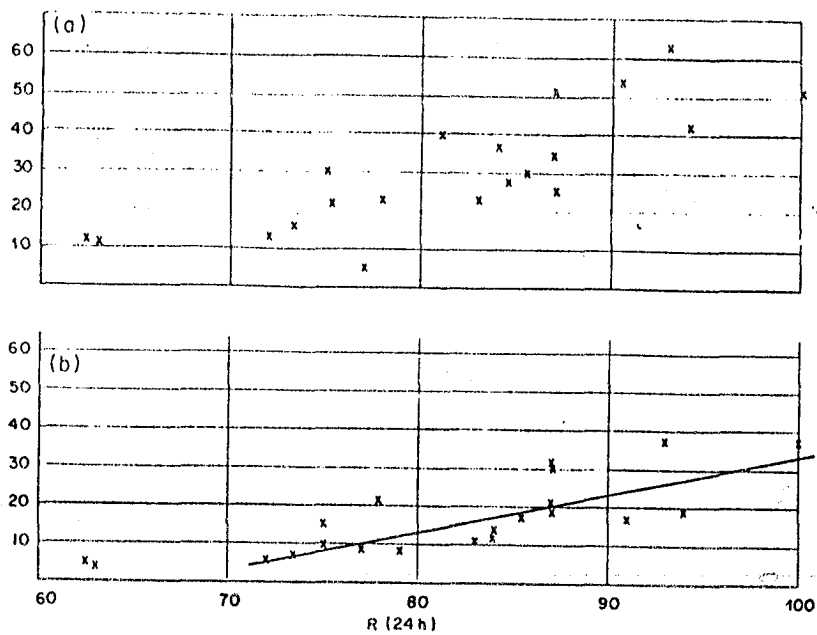


Fig. 13 - Percentage of individuals awakened by plane noise (a) or kept from sleeping (b).